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CLAIM AMENDMENTS

1-31. (Cancelled)

32. (Original) A corona discharge device for an internal combustion engine, the device comprising:

a corona discharge element configured to be disposed in the intake system of an internal combustion engine, the corona discharge element being operable when energized and disposed in air to ionize some of the gases in the air and to create free radicals.

33. (Original) An internal combustion engine with a corona discharge device, comprising:

an engine housing;

a combustion chamber defined in the housing;

an intake system operable to introduce air into the combustion chamber;

a corona discharge device disposed in the intake system, the corona discharge device operable to ionize gasses in the intake system and to create free radicals.

34. (Original) A method of adjusting mixture reactivity of a mixture in a combustion chamber in an internal combustion engine, comprising the steps of:

providing a corona discharge device operable to ionize gases and create free radicals when energized and disposed in the gases;

disposing the corona discharge device in air;

energizing the corona discharge device so as ionize some of the gases in the air and to create free radicals; and

introducing some of the ionized gases and free radicals into the combustion chamber so as to adjust the mixture reactivity of the mixture in the combustion chamber.

35-37. (Cancelled)

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38. (Original) A method of controlling combustion phasing in a homogenous charge compression engine, comprising the steps of:

providing a homogenous charge compression engine of the type operable to compress a combustible mixture of fuel and air until the mixture autoignites without the introduction of a spark, the engine having at least one combustion chamber;

providing a corona discharge device operable to create free radicals and ionize gases when energized and disposed in the gases;

disposing the corona discharge in air;

selectively energizing the corona discharge device to create free radicals and ionize some of the gases in the air;

introducing some of the free radicals and ionized gases into the combustible mixture so as to alter the mixture reactivity of the combustible mixture and to adjust the combustion phasing of the engine; and

adjusting the energizing of the corona discharge device so as to control combustion phasing in the engine.

39. (Original) The method according to claim 39, wherein the engine includes an intake system operable to introduce the combustible mixture, the corona discharge device being disposed in the intake system.

40. (Original) The method according to claim 38, wherein the disposing step comprises disposing the corona discharge device in the combustible mixture of air and fuel.

41-47. (Cancelled)

48. (Original) A rapid compression device for introducing a charge of hot gas into a combustion chamber in an internal combustion engine, the rapid compression device comprising:

a body having a chamber defined therein with an opening communicating with the chamber;

an ignition device operable to ignite a combustible mixture in the secondary chamber; and

a gas permeable spark arrestor disposed in the opening of the chamber such that an ignited combustible mixture in the chamber is extinguished as the mixture is forced through the arrestor.

49. (Original) An internal combustion engine comprising:

a main combustion chamber having an opening defined therein;

a secondary combustion chamber in gaseous communication with the opening in the main combustion chamber;

a ignition device in communication with the secondary combustion chamber for igniting a combustible mixture therein; and

a spark arrestor disposed in the opening in the main combustion chamber, the spark arrestor operable to pass gases therethrough and to extinguish combustion in the gases passed through the opening.

50. (Original) A method of introducing a charge of hot gas into a combustion chamber of an internal combustion engine, the method comprising the steps of:

providing an internal combustion engine having a combustion chamber defined therein;

providing a secondary chamber in gaseous communication with the combustion chamber;

introducing a combustible mixture of air and fuel into the secondary chamber;

combusting the mixture of air and fuel in the secondary chamber so as to produce a hot gaseous combustion product;

passing the combustion product from the secondary chamber to the combustion chamber; and

extinguishing the combustion product so as to create a hot gas as the combustion product passes from the secondary chamber to the combustion chamber;

whereby a hot gas is introduced into the combustion chamber.

51. (Original) The method according to claim 50, further comprising:

providing a spark ignition device in the secondary chamber, the device operable to introduce a spark into the secondary chamber; and

the combusting comprising introducing a spark from the spark ignition device to combust the mixture.

52. (Original) The method according to claim 50, further comprising:

providing a flame arrestor and the extinguishing step comprising passing the combustion product through the flame arrestor.

53. (Original) The method according to claim 50, wherein the combusting step comprises compressing the mixture in the secondary chamber until the mixture autoignites without the introduction of a spark.

54. (Original) A method of introducing pressurized gas into a combustion chamber, comprising:

providing an internal combustion engine having a combustion chamber;

introducing a mixture of air and fuel into the combustion chamber;

compressing the mixture of air and fuel in the combustion chamber;

combusting the mixture of fuel and air in the combustion chamber to create a pressurized gaseous combustion product;

capturing and holding a portion of the pressurized gaseous combustion product;

exhausting substantially all of the remainder of the gaseous combustion product out of the combustion chamber;

introducing a fresh mixture or air and fuel into the combustion chamber;

compressing the fresh mixture in the combustion chamber; and

releasing at least some of the held portion of the pressurized gaseous combustion product into compressed fresh mixture in the combustion chamber.

55. (Original) An internal combustion engine utilizing an HCCI combustion strategy, the engine comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

a first corona discharge device selectively operable to introduce ions and free radicals into the combustible mixture introduced into the first cylinder, thereby altering the mixture reactivity of the combustible mixture in the first cylinder and the combustion phasing for the first cylinder;

a second corona discharge device selectively operable to introduce ions and free radicals into the combustible mixture introduced into the second cylinder, thereby altering the mixture reactivity of the combustible mixture in the second cylinder and the combustion phasing for the second cylinder; and

a controller operable to control the first and second corona discharge devices so as to selectively adjust the relative combustion phasing of the first and second cylinders.

56. (Original) The engine according to claim 55, wherein the intake system includes a first runner for introducing the mixture into the first cylinder and a second runner for introducing the mixture into the second cylinder, the first corona discharge device being disposed in the first runner and the second corona discharge device being disposed in the second cylinder.

57. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

selectively introducing ions and free radicals into the combustible mixture in the first cylinder so as to adjust the mixture reactivity of the combustible mixture and the combustion phasing for the first cylinder;

selectively introducing ions and free radicals into the combustible mixture in the second cylinder so as to adjust the mixture reactivity of the combustible mixture and the combustion phasing for the second cylinder;

controlling the introduction of ions and free radicals to the first and second cylinders so as to selectively adjust the relative combustion phasing of the first and second cylinders.

58. (Original) An internal combustion engine utilizing an HCCI combustion strategy, the engine comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

a first water injector operable to selectively introduce water into the first cylinder, thereby altering the combustion phasing for the first cylinder;

a second water injector operable to selectively introduce water into the second cylinder, thereby altering the combustion phasing for the second cylinder;

a controller operable to control the first and second water injectors so as to selectively adjust the relative combustion phasing of the first and second cylinders.

59. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

selectively introducing water into the first cylinder so as to adjust the combustion phasing for the first cylinder;

selectively introducing water into the second cylinder so as to adjust the combustion phasing for the second cylinder;

controlling the introduction of water into the first and second cylinders so as to selectively adjust the relative combustion phasing of the first and second cylinders.

60. (Original) An internal combustion engine utilizing an HCCI combustion strategy, the engine comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

a first cooling system operable to selectively cool the first cylinder, thereby altering the combustion phasing for the first cylinder;

a second cooling system operable to selectively cool the second cylinder, thereby altering the combustion phasing for the second cylinder;

a controller operable to control the first and second cooling systems so as to selectively adjust the relative combustion phasing of the first and second cylinders.

61. (Original) The internal combustion engine according to claim 60, wherein:

the first cooling system comprises a first coolant supply, first coolant jacket at least partially surrounding the first cylinder and a first coolant control valve for controlling a flow of coolant from the first coolant supply through the first coolant jacket; and

the second cooling system comprises a second coolant supply, a second coolant jacket at least partially surrounding the second cylinder and a second coolant control valve for controlling a flow of coolant from the second coolant supply through the second coolant jacket.

62. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

selectively cooling the first cylinder so as to adjust the combustion phasing for the first cylinder;

selectively cooling the second cylinder so as to adjust the combustion phasing for the second cylinder;

controlling the cooling of the first and second cylinders so as to selectively adjust the relative combustion phasing of the first and second cylinders.

63. (Original) An internal combustion engine utilizing an HCCI combustion strategy, the engine comprising:

an engine housing;

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders, the intake system comprising a first fuel injector for providing fuel for the combustible mixture for the first cylinder and a second fuel injector for providing fuel for the combustible mixture for the second cylinder, the combustible mixture for the first cylinder having a first air-fuel ratio and the combustible mixture for the second cylinder having a second air-fuel ratio;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark; and

a controller operable to control the first and second fuel injectors so as to selectively adjust the air-fuel ratio for the first and second cylinder to adjust the relative combustion phasing of the first and second cylinders.

64. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders, the intake system comprising a first fuel injector for providing fuel for the combustible mixture for the first cylinder and a second fuel injector for providing fuel for the combustible

mixture for the second cylinder, the combustible mixture for the first cylinder having a first air-fuel ratio and the combustible mixture for the second cylinder having a second air-fuel ratio;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

controlling the first and second fuel injectors so as to selectively adjust the air-fuel ratio for the first and second cylinder to adjust the relative combustion phasing of the first and second cylinders.

65. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising:

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark; and

controlling the temperature of the combustible mixture introduced into the first and second cylinders so as to adjust the relative combustion phasing of the first and second cylinders.

66. (Original) The method according to claim 65, wherein the temperature controlling step comprises selectively warming the air in the combustible mixture.

67. (Original) The method according to claim 65, wherein the temperature controlling step comprises selectively mixing warm and cool air for the combustible mixture.

68. (Original) A method of controlling a homogenous charge compression ignition engine, comprising:

providing a homogenous charge compression ignition engine, comprising;

an engine housing

a first and a second cylinder defined in the engine housing;

an intake system operable to introduce a combustible mixture of air and fuel into the cylinders;

a first piston disposed in the first cylinder operable to compress the combustible mixture in the first cylinder until the mixture autoignites without the introduction of a spark;

a second piston disposed in the second cylinder operable to compress the combustible mixture in the second cylinder until the mixture autoignites without the introduction of a spark;

providing an exhaust gas recirculation system operable to selectively introduce exhaust gas into the combustible mixture introduced into the first and second cylinders; and

controlling the exhaust gas recirculation system to selectively control how much exhaust gas is introduced into the combustible mixture introduced into the first and second cylinders so as to adjust the relative combustion phasing of the first and second cylinders.

69. (Original) A homogenous charge compression ignition barrel engine comprising:

an engine housing having a first end and a second end;

a elongated power shaft longitudinally disposed in the engine housing and defining a longitudinal axis of the engine;

a plurality of cylinders surrounding the longitudinal axis, each cylinder having a first and an opposed second open end, each cylinder having a central axis, the first open ends of the cylinders each being generally directed toward the first end of the housing and the second open ends being generally directed toward the second end of the housing;

an intake system operable to introduce a combustible mixture of air and fuel into each of the cylinders;

a first track disposed between the first end of the housing and the first open ends of the cylinders such that a portion of the track is disposed generally in alignment with the central axis of each of the cylinders, the track having a cam surface that longitudinally undulates with respect to the first open ends of the cylinders, a portion of the cam surface being disposed generally in alignment with the central axis of each of the cylinders, the track and the cylinders being rotatable with respect to each other such that the undulating cam surface moves with respect to the first open ends of the cylinders;

a second track disposed between the second end of the housing and the second open ends of the cylinders such that a portion of the track is disposed generally in alignment with the central axis of each of the cylinders, the track having a cam surface that longitudinally undulates with respect to the second open ends of the cylinders, a portion of the cam surface being disposed generally in alignment with the central axis of each of the cylinders, the track and the cylinders being rotatable with respect to each other such that the undulating cam surface moves with respect to the second open ends of the cylinders; and

a first and a second piston movably disposed in each of the cylinders such that a combustion chamber is defined between the first and second pistons, each first piston being in mechanical communication with the cam surface of the first track such that as the cylinders and first track move with respect to each other, the first pistons reciprocate within the cylinders, each second piston being in mechanical communication with the cam surface of the second track such that as the cylinders and second track move with respect to each other, the second pistons reciprocate within the cylinders, the pistons being operable to compress the combustible mixture until the mixture autoignites, without the introduction of a spark.

70. (Original) A homogenous charge compression ignition engine comprising:

an engine housing;

a plurality of chambers each having a first and a second open end;

an intake system operable to introduce a combustible mixture of air and fuel into each of the chambers; and

a first and a second piston movably disposed in each of the cylinders such that a combustion chamber is defined between the first and second pistons; the pistons being operable to compress the combustible mixture until the mixture autoignites, without the introduction of a spark.

71. (Original) A method of sensing combustion phasing in a homogenous charge compression engine comprising:

providing a knock sensor for producing a signal representing the sound and/or vibration from the engine;

correlating the signal from the knock sensor with the combustion phasing of the engine; and

using the correlated signal to determine the combustion phasing of the engine.